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The science objectives of the NEAR Radio Science investigation are to determine the mass of asteroid 433 Eros to better than 0.1%, to determine its bulk density to an accuracy level commensurate with the accuracy of the volume determination (~10%), and to investigate its interior homogeneity by comparing high order gravity fields determined from the shape models with gravity fields determined directly from the spacecraft tracking data. Additional science objectives include the determination of the asteroid's moment of inertia matrix, its rotation state, and placing upper limits upon any outgassing that may have occurred during its 100-year Observational history. If the decision is made to allow the NEAR spacecraft to fly past asteroid 253 Mathilde enroute to its rendezvous with asteroid Eros, the mass and bulk density of Mathilde will also be determined. Coherent, closed loop, X-band tracking data, in combination with the optical navigation and lidar data will provide the necessary measurements.

The radio science objectives of this investigation are more extensive than corresponding investigations of large solar system bodies and there are additional challenges that must be overcome to meet these objectives. For example, the figure of Eros is likely to be very irregular and far from the nearly spherical shapes of the major planets. in addition, the rotation state of the asteroid will not be well known prior to the spacecraft's arrival and the spacecraft orbits about the asteroid are often near the plane-of-sky as seen from the Earth thus limiting the power of the Doppler data to define the gravity field of Eros. Because of these technical challenges and additional ones dictated by the short lead time before launch and the modest budget associated with a Discovery class mission, the NEAR Radio Science Team will work with experienced personnel who have already been tasked with navigating the NEAR spacecraft during the approach and orbiting phases of the mission. The success with which the NEAR Radio Science Team can meet its objectives will depend upon a very close cooperative effort with the JPL Navigation Team. Bobby Williams (NEAR Navigation Team Chief), Steve Synnott (NEAR Optical Navigation Lead), Jim Miller (NEAR Navigation Technical Lead) and Dan Scheeres are experienced NEAR Navigation Team members and all will contribute substantially to the NEAR Radio Science investigations.

Because the NEAR spacecraft will often be confined to orbits about the asteroid that appear nearly in the plane-of-sky as seen from Earth, the spacecraft Doppler data that are normally relied upon to provide the gravity field of the central body will not be as powerful as they would be if the spacecraft were in a different orbital orientation. Hence, inertial landmark data are particularly important for defining the subtle changes in the spacecraft's orbit as it passes over the gravity field of the asteroid. For the same reason, the lidar data will be valuable for gravity field analyses when the spacecraft is in very close orbits about the asteroid. In addition, the asteroid's rotation state will have to be accurately modeled so the subtle differences between the predicted and observed landmark locations in the optical data can be used to refine the gravity model. Ideally, the rotation state would be perfectly known so that these differences would be a direct measure of the unmodeled gravity field. In practice, the Doppler tracking data, optical landmark observations, and lidar observations will have to be used to simultaneously solve for, not only the spacecraft's orbital state, but also the asteroid's rotation state, moment of inertia matrix, and gravity field. This will be an iterative process as the spacecraft orbits evolve closer and closer to the asteroid. This process marks an abrupt departure from the traditional gravity field determination of large, nearly-spherical bodies where the rotation state of the object is accurately known ahead of time and the Doppler data are usually not weakened by nearly plane-of-sky orbits. The modeling of the asteroid's rotation state, moments of inertia, and gravity field are intimately tied to one another so that a successful global solution will require the very close cooperative efforts of, not only the Radio Science Team, but the NEAR Teams representing Navigation, Imaging, and Lidar as well.